

NATIONAL BUREAU OF STANDARDS REPORT

6596

Design and Calibration
of
Luminance Standards
for
P₄ Phosphor

by
Velma I. Burns



U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

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NBS PROJECT

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U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

Report on the Design and Calibration
of
Luminance Standards
for
P₄ Phosphor

1. Scope

This report describes the design and calibration of luminance standards for the calibration of instruments which are used for measuring the luminance of television tubes with P₄ phosphor. One of these standards, designated as a "master" standard, is retained at the National Bureau of Standards. Similar calibrated standards are available for purchase from the NBS.

2. Description of the Luminance Standards

A complete luminance standard consists of: (1) a 500-watt lamp, (2) a 3 1/8-inch square of flashed opal glass bound to a 3 1/8-inch square of Corning 5900 daylight glass. In accordance with the request of the Joint Electron Tube Engineering Council, the relative spectral radiance of the standard is designed to match approximately the relative spectral radiance of a blackbody at a color temperature of 10,000°K. The relative spectral radiances of a blackbody at 10,000°K and of the standards are shown on the accompanying curve sheet.

The lamp is operated at a color temperature of 3000°K and the Corning 5900 daylight glass raises the color temperature of the light from the lamp, transmitted by the opal glass, to approximately 10,000°K.

3. Calibration

3.1 The lamps.

A 500-watt, T20-bulb, inside-frosted lamp having a filament specially constructed for photometric standards is supplied as a part of each luminance standard. The voltage across each lamp required to produce a color temperature of 3000°K was determined by comparing each lamp according to a substitution method with NBS working standards of color temperature. The comparisons were made visually by using the 9° x 13° field of a Lummer-Brodhun photometer.

The luminous intensity and the current for each lamp was then measured at the voltage which had been determined for the 3000°K color temperature. The luminous intensity measurements were made by means of a physical photometer. The physical photometer consists of a thermopile and luminosity filter and is a modified form of the one described in NBS J. Research 27 217 (September 1941) RPL415. For the luminous intensity measurement each lamp was burned base down. The orientation was such that the plane containing the two filament supports was perpendicular to the axis of the photometer. The side of the lamp where the number AA850 is stamped on

the bottom of the bulb was turned away from the photometer. The bottom of the bulb was 4 inches below the photometer axis and the photometric distance (measured to the filament supports) was 1 meter. The voltage, current, and luminous intensity for 3000°K color temperature for each lamp are given in the individual report accompanying each luminance standard.

3.2 The "master" standard.

The "master" standard consists of one of the lamps calibrated as described above and one of the diffusing "sandwiches". Before the parts of this "sandwich" were bound together each glass was measured separately. The spectral transmittances of the Corning 5900 daylight glass were measured on a General Electric recording spectrophotometer. From these data the transmittance of the daylight glass for light of color temperature 3000°K transmitted by the opal glass was computed. The transmittance is 0.098.

The effect of multiple reflections between the daylight glass and the opal glass on the luminance of the "sandwich" was measured as follows. The two glasses and a 500-watt projection lamp were mounted on a photometer bar with the daylight glass about midway between the lamp and the opal glass. The distance between the lamp and the opal glass was about 2 feet. The luminance of the opal glass was measured by a photoelectric photometer. The daylight glass was then placed against the opal glass and the luminance was again measured. The latter measurement was 1.012 times the former and represents the increase in luminance due to multiple reflections between the glasses.

From the transmittance of the daylight glass and the increase in luminance due to multiple reflections the luminance required on the opal glass alone to produce 20fL and 50fL on the "sandwich" when the glasses were bound together was computed. The distance between the 500-watt inside-frosted lamp which is a part of the "master" standard and the opal glass necessary to produce the computed luminance was then determined by means of a Macbeth illuminometer which had been calibrated by using the National Bureau of Standards SB3 luminance standard.

The two glasses were then bound together and used to calibrate similar "sandwiches" which are available for purchase from the National Bureau of Standards. The "master" standard is retained at the NBS and will be available for calibrating more "sandwiches" in case they are needed in the future.

3.3 The "sandwiches".

The "sandwiches" consist of 3 1/8-inch squares of Corning 5900 daylight glass and 3 1/8-inch squares of flashed opal glass similar to those used in the "master" standard. The luminance of each of the "sandwiches"

was determined relative to the luminance of the "master" standard. This was done by means of a photoelectric photometer. Each "sandwich" was placed in turn on a photometer bar at the same distance, about 15 inches, from a 500-watt inside-frosted lamp which is a part of the "master" standard. The lamp was operated at a color temperature of 3000°K and the luminance of each "sandwich" relative to the luminance of the "master" sandwich was measured. The distance required between each "sandwich" and the lamp which is supplied with it was computed from the relative luminance of the "sandwich" and the luminous intensity of the lamp. The distances required for 20fL and for 50fL do not follow precisely the inverse square law. This is to be expected because of the sizes of the components and the distances between them.

4. Using the Standard

It has been determined experimentally that for solid angles of acceptance up to and including the angle viewed by the Weston model 759 Foot Lambert meter, the standards closely approximate the angular distribution of luminance of a perfect diffuser. These standards thus serve to calibrate the Weston model 759 Foot Lambert meter or any instrument which has a smaller solid angle of acceptance; but the readings on the same diffusing area obtained by instruments with markedly different acceptance angles will agree only if that area diffuses light perfectly or nearly perfectly. To obtain by means of an instrument with a small acceptance angle a reading of an imperfect diffuser comparable to that on one with a large acceptance angle, readings on the former at several angles of view sampling the larger acceptance angle should be averaged.

When the model 759 Foot Lambert meter is used care should be taken to center the receiver on the "sandwich".

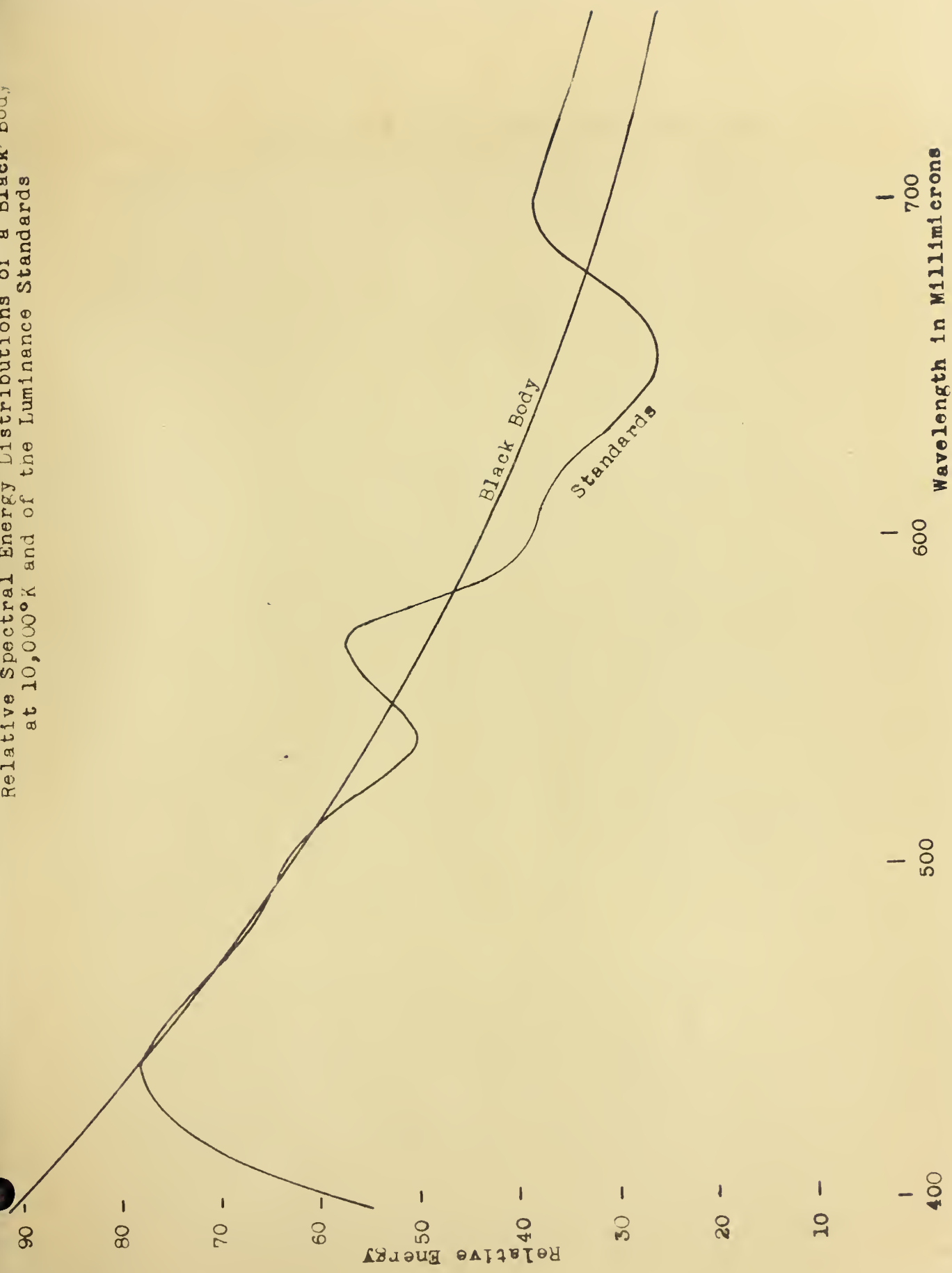
Each luminance standard when issued is accompanied by a report giving the following information.

1. Voltage and current of the lamp for 3000°K color temperature.
2. Luminous intensity of the lamp at the above voltage.
3. Distance between the lamp filament and the flashed opal side of the "sandwich" to produce 20fL.
4. Distance between the lamp filament and the flashed opal side of the "sandwich" to produce 50fL.

The lamps and the opal glass side of the "sandwiches" have been etched with identification numbers.

When a standard is used the glass "sandwich" should be illuminated from the flashed opal side and viewed from the blue-glass side. The "sandwich" should be centered on the photometer axis and the lamp aligned so that its filament supports are perpendicular to the photometer axis with the side of the lamp where the number AA850 is stamped on the bottom of the bulb turned away from the glass "sandwich". The bottom of the lamp should be 4 inches below the photometer axis. (This centers the lamp filament on the photometer axis.) The lamp voltage should be accurately set to the voltage given in the individual report. The distance between the opal glass side of the "sandwich" and the lamp filament should be accurately set to the value given in the report.

Relative Spectral Energy Distributions of a Black Body
at 10,000°K and of the Lumiance Standards



U.S. DEPARTMENT OF COMMERCE

Frederick H. Mueller, *Secretary*

NATIONAL BUREAU OF STANDARDS

A. V. Astin, *Director*



THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its major laboratories in Washington, D.C., and Boulder, Colorado, is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant publications, appears on the inside of the front cover.

WASHINGTON, D.C.

Electricity and Electronics. Resistance and Reactance. Electron Devices. Electrical Instruments. Magnetic Measurements. Dielectrics. Engineering Electronics. Electronic Instrumentation. Electrochemistry.

Optics and Metrology. Photometry and Colorimetry. Photographic Technology. Length. Engineering Metrology.

Heat. Temperature Physics. Thermodynamics. Cryogenic Physics. Rheology. Molecular Kinetics. Free Radicals Research.

Atomic and Radiation Physics. Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics. Neutron Physics. Radiation Theory. Radioactivity. X-rays. High Energy Radiation. Nucleonic Instrumentation. Radiological Equipment.

Chemistry. Organic Coatings. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Molecular Structure and Properties of Gases. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.

Mechanics, Sound. Mechanical Instruments. Fluid Mechanics. Engineering Mechanics. Mass and Scale. Capacity, Density, and Fluid Meters. Combustion Controls.

Organic and Fibrous Materials. Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Plastics. Dental Research.

Metallurgy. Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion. Metal Physics.

Mineral Products. Engineering Ceramics. Glass. Refractories. Enameled Metals. Constitution and Microstructure.

Building Technology. Structural Engineering. Fire Protection. Air Conditioning, Heating, and Refrigeration. Floor, Roof, and Wall Coverings. Codes and Safety Standards. Heat Transfer. Concreting Materials.

Applied Mathematics. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics.

Data Processing Systems. SEAC Engineering Group. Components and Techniques. Digital Circuitry. Digital Systems. Analog Systems. Application Engineering.

• Office of Basic Instrumentation.

• Office of Weights and Measures.

BOULDER, COLORADO

Cryogenic Engineering. Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Gas Liquefaction.

Radio Propagation Physics. Upper Atmosphere Research. Ionospheric Research. Regular Propagation Services. Sun-Earth Relationships. VHF Research. Radio Warning Services. Airglow and Aurora. Radio Astronomy and Arctic Propagation.

Radio Propagation Engineering. Data Reduction Instrumentation. Modulation Research. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Propagation Obstacles Engineering. Radio-Meteorology. Lower Atmosphere Physics.

Radio Standards. High Frequency Electrical Standards. Radio Broadcast Service. High Frequency Impedance Standards. Electronic Calibration Center. Microwave Physics. Microwave Circuit Standards.

Radio Communication and Systems. Low Frequency and Very Low Frequency Research. High Frequency and Very High Frequency Research. Ultra High Frequency and Super High Frequency Research. Modulation Research. Antenna Research. Navigation Systems. Systems Analysis. Field Operations.

